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## **XNDL: METIS Partitioning Process**

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## Introduction

This document describes the partitioning process implemented within the XNDL framework in preparing ns-3 network simulation files for processing on parallel computing clusters at Lawrence Livermore National Laboratory (LLNL). The process employs the METIS graph partitioning tool in assigning network sectors to MPI ranks [1]. This work, conducted by LLNL, addresses a deliverable of the Statement of Work for the Proposed Research in Network Simulation specifically for the Army Research Laboratory under contract L145271.

## 1 Overview

In preparing a simulation input for a parallel run, the network topology must be partitioned and assigned to ranks for processing on the computing cluster. The process flow is shown in Figure 1.

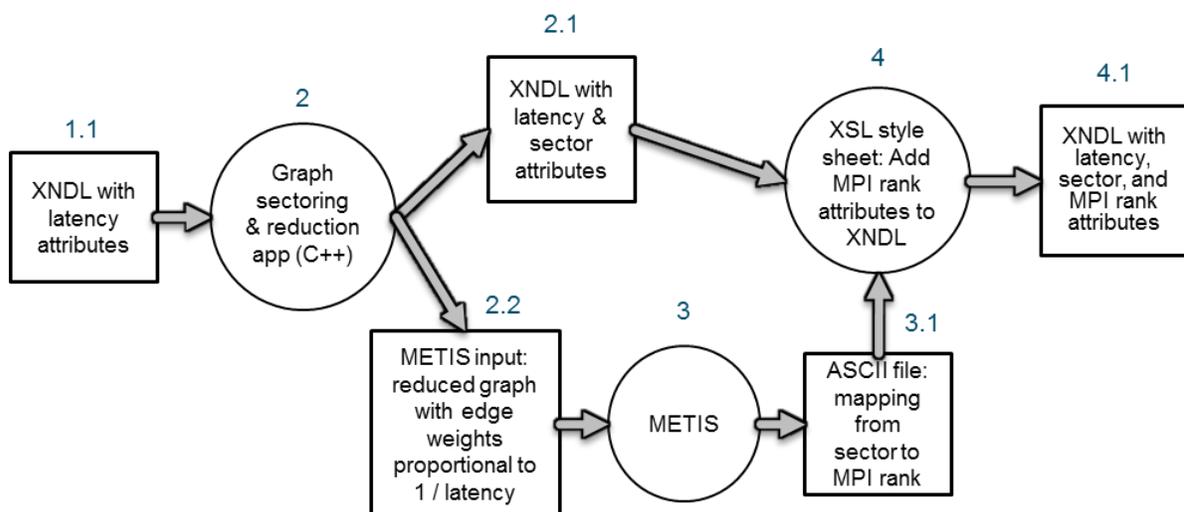


Figure 1: XNDL partitioning process flow. (Annotations correspond to topic sections in this paper.)

For illustration purposes we will assume that we are partitioning an XNDL model in the file `model.xndl` (included in Appendix A).

### 1.1 XNDL input specification with latency attributes

The network model is specified in the `model.xndl` file, with `<NodeContainer>` elements defining the association between sets of nodes (see code Snippet 1: Initial XNDL input specification). These `<NodeContainer>` elements are referenced by `<Subnet>` elements where the `Delay` parameter for the subnet is specified as well as each individual node

Type. (This delay, or latency, will be used to calculate the edge weights for the graph input to METIS in the next iteration of the partitioning toolset.)

```

. . .
<NodeContainer Size="26" Name=ALL_NODES"/>
<NodeContainer Name="csma_1_nodes">
  <RefNode Name="ALL_NODES" Index="0"/>
  <RefNode Name="ALL_NODES" Index="13"/>
</NodeContainer>
<NodeContainer Name="csma_2_nodes">
  <RefNode Name="ALL_NODES" Index="1"/>
  <RefNode Name="ALL_NODES" Index="14"/>
</NodeContainer>
. . .
<Subnet Cidr="10.1.1.0/24" Type="CSMA" Name="csma_1"
  NodeContainer="csma_1_nodes" DataRate="100Mbps" Delay="5ms">
  <Description>csma_1_Subnet</Description>
  <RefNode Type="ROUTER" DnsName="router1.llnl.gov" Index="0">
    <IPAddress>10.1.1.1</IPAddress>
  </RefNode>
  <RefNode Type="SIMPLE" DnsName="node14.llnl.gov" Index="1">
    <IPAddress>10.1.1.2</IPAddress>
  </RefNode>
</Subnet>
<Subnet Cidr="10.1.2.0/24" Type="CSMA" Name="csma_2"
  NodeContainer="csma_2_nodes" DataRate="100Mbps" Delay="12ms">
  <Description>csma_2_Subnet</Description>
  <RefNode Type="ROUTER" DnsName="router2.llnl.gov" Index="0">
    <IPAddress>10.1.2.1</IPAddress>
  </RefNode>
  <RefNode Type="SIMPLE" DnsName="node15.llnl.gov" Index="1">
    <IPAddress>10.1.2.2</IPAddress>
  </RefNode>
</Subnet>
. . .

```

Snippet 1: Initial XNDL input specification

## 2 Graph sectoring and reduction application

The `sector` program is a stand-alone application that adds sector attributes to `<NodeContainers>` for which the associated set of nodes must reside on the same sector (e.g. `csma` nodes) and adds sector attributes to individual `<refnodes>` that can be placed in a separate sector from other nodes contained in their parent `<NodeContainer>` (e.g. `P2P` nodes). Logic exists to handle bridged `csma` channels, which

should be placed in the same sector, as well as the handling of router-only nodes, which belong in independent sectors.

## 2.1 XNDL with sector attributes

The sector-annotated XNDL is output as `model.sector.xndl` (see Snippet 2: XNDL output from graph sectoring tool), as well as a sector graph in METIS input format.

```

. . .

<NodeContainer Name="csma_1_nodes" Sector="1">
  <RefNode Name="ALL_NODES" Index="0"/>
  <RefNode Name="ALL_NODES" Index="13"/>
</NodeContainer>
<NodeContainer Name="csma_2_nodes" Sector="2">
  <RefNode Name="ALL_NODES" Index="1"/>
  <RefNode Name="ALL_NODES" Index="14"/>
</NodeContainer>

. . .

```

Snippet 2: XNDL output from graph sectoring tool

## 2.2 METIS input: reduced graph with edge weights

The graph sectoring tool also produces an input file for the METIS partitioning: `model.sector.metis` (see Snippet 3: Graph sectoring tool output file for METIS input).

```

% Metis graph file derived from graph 'SimTest Sectors'
% <number of vertices> <number of edges> <fmt-weights> <ncon>
12 23
% edges for each vertex (starting with vertex 1)
2 8 3 7 9
1 3 4 5 6 10
2 11 1 5
2 5 8
4 2 3 11 12
2 10 8
8 1
1 6 7 9 4 11
8 1 11
6 11 2
3 9 10 8 5
5
% last vertex:      12 (should equal <number of vertices>)
% last adjacency:  46 (should be 2 * <number of edges>)

```

Snippet 3: Graph sectoring tool output file for METIS input

The sector-labeled XML description file `model.sector.xndl` and the Metis input file `model.sector.metis` can be reused for different partitioning strategies, different numbers of MPI ranks, or different partitioning functions.

### 3 METIS

The METIS graph partitioning tool is used to assign sectors to MPI ranks based on its partitioning logic [1]. A typical command line to partition the model into 4 ranks would be:

```
$ gpmetis model.sector.metis 4
```

#### 3.1 METIS Output: Mapping sector to MPI rank

The output of `gpmetis` is written to `model.sector.metis.part.3` (see Snippet 4: METIS output file) .

```
0
2
1
2
1
2
0
0
0
2
1
1
```

Snippet 4: METIS output file

The sector number corresponds to the row in the output file. For instance, with this partitioning sector 1 will be assigned to rank 0, sector 2 assigned to rank 2, *etc.*

### 4 XSL Style Sheet: Add MPI attributes to XNDL

To produce the final simulation input specification file a python script, `AddSystemId.py`, takes as input: `model.sector.xndl` file, the XNDL with section attributes, an XSLT transform to apply the sector-to-rank assignments, and the METIS output file, `model.sector.metis.part.3`. In order for the XSLT transform to process the METIS output file it must first *XMLize* the file by simply adding XML tags to the rank entries. (See Snippet 5: XMLized METIS output file)

```
<!-- METIS output rank assignments -->
  <ranks>
    <rank>0</rank>
    <rank>2</rank>
    <rank>1</rank>
    <rank>2</rank>
    <rank>1</rank>
    <rank>2</rank>
    <rank>0</rank>
    <rank>0</rank>
    <rank>0</rank>
    <rank>2</rank>
    <rank>1</rank>
    <rank>1</rank>
  </ranks>
```

**Snippet 5: XMLized METIS output file**

The result of *XMLizing* the Metis output file is saved as `model.sector.metis.part.3.xml`.

The XSLT transform is then invoked to add the `SystemId` attribute to the `<NodeContainers>` and/or `<RefNode>` elements of the XNDL file.

The syntax of the Python script is:

```
$ python addSystemId.py -x [XNDL Sector file] -t [XSLT transform file]
-m [METIS sector to rank map file]
```

#### 4.1 XNDL with latency, sector, and MPI attributes

Output is written to `stdout` so can be redirected to create the final XNDL simulation input file, which would typically be saved as `model.sector.metis.part.3.xndl`. (See Snippet 6: Final simulation input file)

```
. . .

<NodeContainer Name="csma_1_nodes" Sector="1" SystemId="0">
  <RefNode Name="ALL_NODES" Index="0"/>
  <RefNode Name="ALL_NODES" Index="13"/>
</NodeContainer>
<NodeContainer Name="csma_2_nodes" Sector="2" SystemId="2">
  <RefNode Name="ALL_NODES" Index="1"/>
  <RefNode Name="ALL_NODES" Index="14"/>
</NodeContainer>

. . .
```

**Snippet 6: Final simulation input file**

The final output XNDL is now fully annotated for a MPI-based simulation.

## 5 Bibliography

- [1] Karypis Lab, "METIS - Serial Graph Partitioning and Fill-reducing Matrix Ordering," 30 3 2013. [Online]. Available:  
<http://glaros.dtc.umn.edu/gkhome/metis/metis/overview>. [Accessed 25 4 2013].
- [2] L. Banks, P. Barnes, D. Jefferson and S. Nikolaev, "XML Network Description Language (XNDL) for ns-3," 2013.

## Appendix A. Initial XNDL input file

```

<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<!--Simulation XML file -->
<NetSim xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="NetSim.xsd" SchemaVersion="1.0" Name="SimTest"
CsmaEnableAsciiTraceAll="false" CsmaEnablePcapAll="false"
P2pEnableAsciiTraceAll="false" P2pEnablePcapAll="false">
  <NodeContainer Size="26" Name="ALL_NODES"/>
  <NodeContainer Name="csma_1_nodes">
    <RefNode Name="ALL_NODES" Index="0"/>
    <RefNode Name="ALL_NODES" Index="13"/>
  </NodeContainer>
  <NodeContainer Name="csma_2_nodes">
    <RefNode Name="ALL_NODES" Index="1"/>
    <RefNode Name="ALL_NODES" Index="14"/>
  </NodeContainer>
  <NodeContainer Name="csma_3_nodes" Size="2">
    <RefNode Name="ALL_NODES" Index="2"/>
    <RefNode Name="ALL_NODES" Index="15"/>
  </NodeContainer>
  <NodeContainer Name="csma_4_nodes">
    <RefNode Name="ALL_NODES" Index="3"/>
    <RefNode Name="ALL_NODES" Index="16"/>
    <ApplicationSet Name="WebBrowsingSet3_0" Index="0"/>
    <ApplicationSet Name="WebBrowsingSet3_1" Index="1"/>
  </NodeContainer>
  <NodeContainer Name="csma_5_nodes">
    <RefNode Name="ALL_NODES" Index="4"/>
    <RefNode Name="ALL_NODES" Index="17"/>
  </NodeContainer>
  <NodeContainer Name="csma_6_nodes">
    <RefNode Name="ALL_NODES" Index="5"/>
    <RefNode Name="ALL_NODES" Index="18"/>
    <ApplicationSet Name="WebBrowsingSet4_0" Index="0"/>
    <ApplicationSet Name="WebBrowsingSet4_1" Index="1"/>
  </NodeContainer>
  <NodeContainer Name="csma_7_nodes">
    <RefNode Name="ALL_NODES" Index="6"/>
    <RefNode Name="ALL_NODES" Index="19"/>
    <RefNode Name="ALL_NODES" Index="17"/>
    <RefNode Name="ALL_NODES" Index="14"/>
    <ApplicationSet Name="WebBrowsingSet10_0" Index="0"/>
    <ApplicationSet Name="WebBrowsingSet10_1" Index="1"/>
  </NodeContainer>
  <NodeContainer Name="csma_8_nodes">
    <RefNode Name="ALL_NODES" Index="7"/>
    <RefNode Name="ALL_NODES" Index="20"/>
  </NodeContainer>
  <NodeContainer Name="csma_9_nodes">
    <RefNode Name="ALL_NODES" Index="8"/>
    <RefNode Name="ALL_NODES" Index="21"/>
  </NodeContainer>
  <NodeContainer Name="csma_10_nodes">
    <RefNode Name="ALL_NODES" Index="9"/>
    <RefNode Name="ALL_NODES" Index="22"/>
  </NodeContainer>
  <NodeContainer Name="csma_11_nodes">
    <RefNode Name="ALL_NODES" Index="10"/>
    <RefNode Name="ALL_NODES" Index="23"/>
    <ApplicationSet Name="WebBrowsingSet6_0" Index="0"/>

```

```

        <ApplicationSet Name="WebBrowsingSet6_1" Index="1"/>
</NodeContainer>
<NodeContainer Name="csma_12_nodes">
    <RefNode Name="ALL_NODES" Index="11"/>
    <RefNode Name="ALL_NODES" Index="24"/>
    <ApplicationSet Name="WebBrowsingSet5_0" Index="0"/>
    <ApplicationSet Name="WebBrowsingSet5_1" Index="1"/>
</NodeContainer>
<NodeContainer Name="csma_13_nodes">
    <RefNode Name="ALL_NODES" Index="12"/>
    <RefNode Name="ALL_NODES" Index="25"/>
    <ApplicationSet Name="WebBrowsingSet2_0" Index="0"/>
    <ApplicationSet Name="WebBrowsingSet2_1" Index="1"/>
</NodeContainer>
<NodeContainer Name="p2p_14_nodes">
    <RefNode Name="ALL_NODES" Index="0"/>
    <RefNode Name="ALL_NODES" Index="1"/>
    <ApplicationSet Name="WebBrowsingSet7_0" Index="0"/>
    <ApplicationSet Name="WebBrowsingSet7_1" Index="1"/>
</NodeContainer>
<NodeContainer Name="p2p_15_nodes">
    <RefNode Name="ALL_NODES" Index="1"/>
    <RefNode Name="ALL_NODES" Index="2"/>
</NodeContainer>
<NodeContainer Name="p2p_16_nodes">
    <RefNode Name="ALL_NODES" Index="2"/>
    <RefNode Name="ALL_NODES" Index="12"/>
</NodeContainer>
<NodeContainer Name="p2p_17_nodes">
    <RefNode Name="ALL_NODES" Index="3"/>
    <RefNode Name="ALL_NODES" Index="4"/>
</NodeContainer>
<NodeContainer Name="p2p_18_nodes">
    <RefNode Name="ALL_NODES" Index="4"/>
    <RefNode Name="ALL_NODES" Index="5"/>
</NodeContainer>
<NodeContainer Name="p2p_19_nodes">
    <RefNode Name="ALL_NODES" Index="5"/>
    <RefNode Name="ALL_NODES" Index="6"/>
</NodeContainer>
<NodeContainer Name="p2p_20_nodes">
    <RefNode Name="ALL_NODES" Index="6"/>
    <RefNode Name="ALL_NODES" Index="7"/>
</NodeContainer>
<NodeContainer Name="p2p_21_nodes">
    <RefNode Name="ALL_NODES" Index="7"/>
    <RefNode Name="ALL_NODES" Index="11"/>
</NodeContainer>
<NodeContainer Name="p2p_22_nodes">
    <RefNode Name="ALL_NODES" Index="8"/>
    <RefNode Name="ALL_NODES" Index="9"/>
</NodeContainer>
<NodeContainer Name="p2p_23_nodes">
    <RefNode Name="ALL_NODES" Index="9"/>
    <RefNode Name="ALL_NODES" Index="10"/>
</NodeContainer>
<NodeContainer Name="p2p_24_nodes">
    <RefNode Name="ALL_NODES" Index="10"/>
    <RefNode Name="ALL_NODES" Index="0"/>
</NodeContainer>
<NodeContainer Name="p2p_25_nodes">
    <RefNode Name="ALL_NODES" Index="11"/>
    <RefNode Name="ALL_NODES" Index="12"/>

```

```

</NodeContainer>
<NodeContainer Name="p2p_26_nodes">
  <RefNode Name="ALL_NODES" Index="12"/>
  <RefNode Name="ALL_NODES" Index="9"/>
</NodeContainer>
<NodeContainer Name="p2p_27_nodes">
  <RefNode Name="ALL_NODES" Index="0"/>
  <RefNode Name="ALL_NODES" Index="9"/>
</NodeContainer>
<NodeContainer Name="p2p_28_nodes">
  <RefNode Name="ALL_NODES" Index="1"/>
  <RefNode Name="ALL_NODES" Index="4"/>
  <ApplicationSet Name="WebBrowsingSet9_0" Index="0"/>
  <ApplicationSet Name="WebBrowsingSet9_1" Index="1"/>
</NodeContainer>
<NodeContainer Name="p2p_29_nodes">
  <RefNode Name="ALL_NODES" Index="2"/>
  <RefNode Name="ALL_NODES" Index="0"/>
</NodeContainer>
<NodeContainer Name="p2p_30_nodes">
  <RefNode Name="ALL_NODES" Index="3"/>
  <RefNode Name="ALL_NODES" Index="5"/>
</NodeContainer>
<NodeContainer Name="p2p_31_nodes">
  <RefNode Name="ALL_NODES" Index="4"/>
  <RefNode Name="ALL_NODES" Index="6"/>
  <ApplicationSet Name="WebBrowsingSet0_0" Index="0"/>
  <ApplicationSet Name="WebBrowsingSet0_1" Index="1"/>
</NodeContainer>
<NodeContainer Name="p2p_32_nodes">
  <RefNode Name="ALL_NODES" Index="5"/>
  <RefNode Name="ALL_NODES" Index="2"/>
</NodeContainer>
<NodeContainer Name="p2p_33_nodes">
  <RefNode Name="ALL_NODES" Index="6"/>
  <RefNode Name="ALL_NODES" Index="2"/>
</NodeContainer>
<NodeContainer Name="p2p_34_nodes">
  <RefNode Name="ALL_NODES" Index="7"/>
  <RefNode Name="ALL_NODES" Index="9"/>
</NodeContainer>
<NodeContainer Name="p2p_35_nodes">
  <RefNode Name="ALL_NODES" Index="8"/>
  <RefNode Name="ALL_NODES" Index="0"/>
  <ApplicationSet Name="WebBrowsingSet1_0" Index="0"/>
  <ApplicationSet Name="WebBrowsingSet1_1" Index="1"/>
</NodeContainer>
<NodeContainer Name="p2p_36_nodes">
  <RefNode Name="ALL_NODES" Index="9"/>
  <RefNode Name="ALL_NODES" Index="3"/>
</NodeContainer>
<NodeContainer Name="p2p_37_nodes">
  <RefNode Name="ALL_NODES" Index="10"/>
  <RefNode Name="ALL_NODES" Index="12"/>
  <ApplicationSet Name="WebBrowsingSet8_0" Index="0"/>
  <ApplicationSet Name="WebBrowsingSet8_1" Index="1"/>
</NodeContainer>
<NodeContainer Name="p2p_38_nodes">
  <RefNode Name="ALL_NODES" Index="11"/>
  <RefNode Name="ALL_NODES" Index="4"/>
</NodeContainer>
<NodeContainer Name="p2p_39_nodes">
  <RefNode Name="ALL_NODES" Index="12"/>

```

```

        <RefNode Name="ALL_NODES" Index="5"/>
    </NodeContainer>
    <NodeContainer Name="p2p_40_nodes" Size="1">
        <RefNode Name="ALL_NODES" Index="5"/>
    </NodeContainer>
    <Subnet Cidr="10.1.1.0/24" Type="CSMA" Name="csma_1"
NodeContainer="csma_1_nodes" DataRate="100Mbps" Delay="5ms">
        <Description>csma_1_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router1.llnl.gov" Index="0">
            <IPAddress>10.1.1.1</IPAddress>
        </RefNode>
        <RefNode Type="SIMPLE" DnsName="node14.llnl.gov" Index="1">
            <IPAddress>10.1.1.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.2.0/24" Type="CSMA" Name="csma_2"
NodeContainer="csma_2_nodes" DataRate="100Mbps" Delay="12ms">
        <Description>csma_2_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router2.llnl.gov" Index="0">
            <IPAddress>10.1.2.1</IPAddress>
        </RefNode>
        <RefNode Type="SIMPLE" DnsName="node15.llnl.gov" Index="1">
            <IPAddress>10.1.2.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.3.0/24" Type="CSMA" Name="csma_3"
NodeContainer="csma_3_nodes" DataRate="100Mbps" Delay="2ms">
        <Description>csma_3_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router3.llnl.gov" Index="0">
            <IPAddress>10.1.3.1</IPAddress>
        </RefNode>
        <RefNode Type="SIMPLE" DnsName="node16.llnl.gov" Index="1">
            <IPAddress>10.1.3.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.4.0/24" Type="CSMA" Name="csma_4"
NodeContainer="csma_4_nodes" DataRate="100Mbps" Delay="8ms">
        <Description>csma_4_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router4.llnl.gov" Index="0">
            <IPAddress>10.1.4.1</IPAddress>
        </RefNode>
        <RefNode Type="SIMPLE" DnsName="node17.llnl.gov" Index="1">
            <IPAddress>10.1.4.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.5.0/24" Type="CSMA" Name="csma_5"
NodeContainer="csma_5_nodes" DataRate="100Mbps" Delay="6ms">
        <Description>csma_5_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router5.llnl.gov" Index="0">
            <IPAddress>10.1.5.1</IPAddress>
        </RefNode>
        <RefNode Type="SIMPLE" DnsName="node18.llnl.gov" Index="1">
            <IPAddress>10.1.5.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.6.0/24" Type="CSMA" Name="csma_6"
NodeContainer="csma_6_nodes" DataRate="100Mbps" Delay="9ms">
        <Description>csma_6_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router6.llnl.gov" Index="0">
            <IPAddress>10.1.6.1</IPAddress>
        </RefNode>
        <RefNode Type="SIMPLE" DnsName="node19.llnl.gov" Index="1">
            <IPAddress>10.1.6.2</IPAddress>

```

```

        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.7.0/24" Type="CSMA" Name="csma_7"
NodeContainer="csma_7_nodes" DataRate="100Mbps" Delay="8ms">
    <Description>csma_7_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router7.llnl.gov" Index="0">
        <IPAddress>10.1.7.1</IPAddress>
    </RefNode>
    <RefNode Type="SIMPLE" DnsName="node20.llnl.gov" Index="1">
        <IPAddress>10.1.7.2</IPAddress>
    </RefNode>
</Subnet>
    <Subnet Cidr="10.1.8.0/24" Type="CSMA" Name="csma_8"
NodeContainer="csma_8_nodes" DataRate="100Mbps" Delay="9ms">
    <Description>csma_8_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router8.llnl.gov" Index="0">
        <IPAddress>10.1.8.1</IPAddress>
    </RefNode>
    <RefNode Type="SIMPLE" DnsName="node21.llnl.gov" Index="1">
        <IPAddress>10.1.8.2</IPAddress>
    </RefNode>
</Subnet>
    <Subnet Cidr="10.1.9.0/24" Type="CSMA" Name="csma_9"
NodeContainer="csma_9_nodes" DataRate="100Mbps" Delay="3ms">
    <Description>csma_9_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router9.llnl.gov" Index="0">
        <IPAddress>10.1.9.1</IPAddress>
    </RefNode>
    <RefNode Type="SIMPLE" DnsName="node22.llnl.gov" Index="1">
        <IPAddress>10.1.9.2</IPAddress>
    </RefNode>
</Subnet>
    <Subnet Cidr="10.1.10.0/24" Type="CSMA" Name="csma_10"
NodeContainer="csma_10_nodes" DataRate="100Mbps" Delay="12ms">
    <Description>csma_10_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router10.llnl.gov" Index="0">
        <IPAddress>10.1.10.1</IPAddress>
    </RefNode>
    <RefNode Type="SIMPLE" DnsName="node23.llnl.gov" Index="1">
        <IPAddress>10.1.10.2</IPAddress>
    </RefNode>
</Subnet>
    <Subnet Cidr="10.1.11.0/24" Type="CSMA" Name="csma_11"
NodeContainer="csma_11_nodes" DataRate="100Mbps" Delay="7ms">
    <Description>csma_11_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router11.llnl.gov" Index="0">
        <IPAddress>10.1.11.1</IPAddress>
    </RefNode>
    <RefNode Type="SIMPLE" DnsName="node24.llnl.gov" Index="1">
        <IPAddress>10.1.11.2</IPAddress>
    </RefNode>
</Subnet>
    <Subnet Cidr="10.1.12.0/24" Type="CSMA" Name="csma_12"
NodeContainer="csma_12_nodes" DataRate="100Mbps" Delay="9ms">
    <Description>csma_12_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router12.llnl.gov" Index="0">
        <IPAddress>10.1.12.1</IPAddress>
    </RefNode>
    <RefNode Type="SIMPLE" DnsName="node25.llnl.gov" Index="1">
        <IPAddress>10.1.12.2</IPAddress>
    </RefNode>
</Subnet>

```

```

    <Subnet Cidr="10.1.13.0/24" Type="CSMA" Name="csma_13"
NodeContainer="csma_13_nodes" DataRate="100Mbps" Delay="11ms">
    <Description>csma_13_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router13.llnl.gov" Index="0">
        <IPAddress>10.1.13.1</IPAddress>
    </RefNode>
    <RefNode Type="SIMPLE" DnsName="node26.llnl.gov" Index="1">
        <IPAddress>10.1.13.2</IPAddress>
    </RefNode>
</Subnet>
    <Subnet Cidr="10.1.14.0/24" Type="P2P" Name="p2p_14"
NodeContainer="p2p_14_nodes" DataRate="100Mbps" Delay="4ms">
    <Description>p2p_14_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router1.llnl.gov" Index="0">
        <IPAddress>10.1.14.1</IPAddress>
    </RefNode>
    <RefNode Type="ROUTER" DnsName="router2.llnl.gov" Index="1">
        <IPAddress>10.1.14.2</IPAddress>
    </RefNode>
</Subnet>
    <Subnet Cidr="10.1.15.0/24" Type="P2P" Name="p2p_15"
NodeContainer="p2p_15_nodes" DataRate="100Mbps" Delay="6ms">
    <Description>p2p_15_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router2.llnl.gov" Index="0">
        <IPAddress>10.1.15.1</IPAddress>
    </RefNode>
    <RefNode Type="ROUTER" DnsName="router3.llnl.gov" Index="1">
        <IPAddress>10.1.15.2</IPAddress>
    </RefNode>
</Subnet>
    <Subnet Cidr="10.1.16.0/24" Type="P2P" Name="p2p_16"
NodeContainer="p2p_16_nodes" DataRate="100Mbps" Delay="10ms">
    <Description>p2p_16_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router3.llnl.gov" Index="0">
        <IPAddress>10.1.16.1</IPAddress>
    </RefNode>
    <RefNode Type="ROUTER" DnsName="router13.llnl.gov" Index="1">
        <IPAddress>10.1.16.2</IPAddress>
    </RefNode>
</Subnet>
    <Subnet Cidr="10.1.17.0/24" Type="P2P" Name="p2p_17"
NodeContainer="p2p_17_nodes" DataRate="100Mbps" Delay="3ms">
    <Description>p2p_17_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router4.llnl.gov" Index="0">
        <IPAddress>10.1.17.1</IPAddress>
    </RefNode>
    <RefNode Type="ROUTER" DnsName="router5.llnl.gov" Index="1">
        <IPAddress>10.1.17.2</IPAddress>
    </RefNode>
</Subnet>
    <Subnet Cidr="10.1.18.0/24" Type="P2P" Name="p2p_18"
NodeContainer="p2p_18_nodes" DataRate="100Mbps" Delay="4ms">
    <Description>p2p_18_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router5.llnl.gov" Index="0">
        <IPAddress>10.1.18.1</IPAddress>
    </RefNode>
    <RefNode Type="ROUTER" DnsName="router6.llnl.gov" Index="1">
        <IPAddress>10.1.18.2</IPAddress>
    </RefNode>
</Subnet>
    <Subnet Cidr="10.1.19.0/24" Type="P2P" Name="p2p_19"
NodeContainer="p2p_19_nodes" DataRate="100Mbps" Delay="3ms">
    <Description>p2p_19_Subnet</Description>

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        <RefNode Type="ROUTER" DnsName="router6.llnl.gov" Index="0">
            <IPAddress>10.1.19.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router7.llnl.gov" Index="1">
            <IPAddress>10.1.19.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.20.0/24" Type="P2P" Name="p2p_20"
NodeContainer="p2p_20_nodes" DataRate="100Mbps" Delay="3ms">
        <Description>p2p_20_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router7.llnl.gov" Index="0">
            <IPAddress>10.1.20.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router8.llnl.gov" Index="1">
            <IPAddress>10.1.20.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.21.0/24" Type="P2P" Name="p2p_21"
NodeContainer="p2p_21_nodes" DataRate="100Mbps" Delay="5ms">
        <Description>p2p_21_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router8.llnl.gov" Index="0">
            <IPAddress>10.1.21.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router12.llnl.gov" Index="1">
            <IPAddress>10.1.21.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.22.0/24" Type="P2P" Name="p2p_22"
NodeContainer="p2p_22_nodes" DataRate="100Mbps" Delay="7ms">
        <Description>p2p_22_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router9.llnl.gov" Index="0">
            <IPAddress>10.1.22.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router10.llnl.gov" Index="1">
            <IPAddress>10.1.22.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.23.0/24" Type="P2P" Name="p2p_23"
NodeContainer="p2p_23_nodes" DataRate="100Mbps" Delay="11ms">
        <Description>p2p_23_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router10.llnl.gov" Index="0">
            <IPAddress>10.1.23.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router11.llnl.gov" Index="1">
            <IPAddress>10.1.23.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.24.0/24" Type="P2P" Name="p2p_24"
NodeContainer="p2p_24_nodes" DataRate="100Mbps" Delay="2ms">
        <Description>p2p_24_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router11.llnl.gov" Index="0">
            <IPAddress>10.1.24.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router1.llnl.gov" Index="1">
            <IPAddress>10.1.24.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.25.0/24" Type="P2P" Name="p2p_25"
NodeContainer="p2p_25_nodes" DataRate="100Mbps" Delay="10ms">
        <Description>p2p_25_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router12.llnl.gov" Index="0">
            <IPAddress>10.1.25.1</IPAddress>
        </RefNode>

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        <RefNode Type="ROUTER" DnsName="router13.llnl.gov" Index="1">
            <IPAddress>10.1.25.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.26.0/24" Type="P2P" Name="p2p_26"
NodeContainer="p2p_26_nodes" DataRate="100Mbps" Delay="3ms">
        <Description>p2p_26_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router13.llnl.gov" Index="0">
            <IPAddress>10.1.26.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router10.llnl.gov" Index="1">
            <IPAddress>10.1.26.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.27.0/24" Type="P2P" Name="p2p_27"
NodeContainer="p2p_27_nodes" DataRate="100Mbps" Delay="8ms">
        <Description>p2p_27_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router1.llnl.gov" Index="0">
            <IPAddress>10.1.27.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router10.llnl.gov" Index="1">
            <IPAddress>10.1.27.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.28.0/24" Type="P2P" Name="p2p_28"
NodeContainer="p2p_28_nodes" DataRate="100Mbps" Delay="5ms">
        <Description>p2p_28_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router2.llnl.gov" Index="0">
            <IPAddress>10.1.28.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router5.llnl.gov" Index="1">
            <IPAddress>10.1.28.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.29.0/24" Type="P2P" Name="p2p_29"
NodeContainer="p2p_29_nodes" DataRate="100Mbps" Delay="5ms">
        <Description>p2p_29_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router3.llnl.gov" Index="0">
            <IPAddress>10.1.29.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router1.llnl.gov" Index="1">
            <IPAddress>10.1.29.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.30.0/24" Type="P2P" Name="p2p_30"
NodeContainer="p2p_30_nodes" DataRate="100Mbps" Delay="7ms">
        <Description>p2p_30_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router4.llnl.gov" Index="0">
            <IPAddress>10.1.30.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router6.llnl.gov" Index="1">
            <IPAddress>10.1.30.2</IPAddress>
        </RefNode>
    </Subnet>
    <Subnet Cidr="10.1.31.0/24" Type="P2P" Name="p2p_31"
NodeContainer="p2p_31_nodes" DataRate="100Mbps" Delay="11ms">
        <Description>p2p_31_Subnet</Description>
        <RefNode Type="ROUTER" DnsName="router5.llnl.gov" Index="0">
            <IPAddress>10.1.31.1</IPAddress>
        </RefNode>
        <RefNode Type="ROUTER" DnsName="router7.llnl.gov" Index="1">
            <IPAddress>10.1.31.2</IPAddress>
        </RefNode>
    </Subnet>

```

```

</Subnet>
<Subnet Cidr="10.1.32.0/24" Type="P2P" Name="p2p_32"
NodeContainer="p2p_32_nodes" DataRate="100Mbps" Delay="9ms">
  <Description>p2p_32_Subnet</Description>
  <RefNode Type="ROUTER" DnsName="router6.llnl.gov" Index="0">
    <IPAddress>10.1.32.1</IPAddress>
  </RefNode>
  <RefNode Type="ROUTER" DnsName="router3.llnl.gov" Index="1">
    <IPAddress>10.1.32.2</IPAddress>
  </RefNode>
</Subnet>
<Subnet Cidr="10.1.33.0/24" Type="P2P" Name="p2p_33"
NodeContainer="p2p_33_nodes" DataRate="100Mbps" Delay="11ms">
  <Description>p2p_33_Subnet</Description>
  <RefNode Type="ROUTER" DnsName="router7.llnl.gov" Index="0">
    <IPAddress>10.1.33.1</IPAddress>
  </RefNode>
  <RefNode Type="ROUTER" DnsName="router3.llnl.gov" Index="1">
    <IPAddress>10.1.33.2</IPAddress>
  </RefNode>
</Subnet>
<Subnet Cidr="10.1.34.0/24" Type="P2P" Name="p2p_34"
NodeContainer="p2p_34_nodes" DataRate="100Mbps" Delay="4ms">
  <Description>p2p_34_Subnet</Description>
  <RefNode Type="ROUTER" DnsName="router8.llnl.gov" Index="0">
    <IPAddress>10.1.34.1</IPAddress>
  </RefNode>
  <RefNode Type="ROUTER" DnsName="router10.llnl.gov" Index="1">
    <IPAddress>10.1.34.2</IPAddress>
  </RefNode>
</Subnet>
<Subnet Cidr="10.1.35.0/24" Type="P2P" Name="p2p_35"
NodeContainer="p2p_35_nodes" DataRate="100Mbps" Delay="5ms">
  <Description>p2p_35_Subnet</Description>
  <RefNode Type="ROUTER" DnsName="router9.llnl.gov" Index="0">
    <IPAddress>10.1.35.1</IPAddress>
  </RefNode>
  <RefNode Type="ROUTER" DnsName="router1.llnl.gov" Index="1">
    <IPAddress>10.1.35.2</IPAddress>
  </RefNode>
</Subnet>
<Subnet Cidr="10.1.36.0/24" Type="P2P" Name="p2p_36"
NodeContainer="p2p_36_nodes" DataRate="100Mbps" Delay="5ms">
  <Description>p2p_36_Subnet</Description>
  <RefNode Type="ROUTER" DnsName="router10.llnl.gov" Index="0">
    <IPAddress>10.1.36.1</IPAddress>
  </RefNode>
  <RefNode Type="ROUTER" DnsName="router4.llnl.gov" Index="1">
    <IPAddress>10.1.36.2</IPAddress>
  </RefNode>
</Subnet>
<Subnet Cidr="10.1.37.0/24" Type="P2P" Name="p2p_37"
NodeContainer="p2p_37_nodes" DataRate="100Mbps" Delay="5ms">
  <Description>p2p_37_Subnet</Description>
  <RefNode Type="ROUTER" DnsName="router11.llnl.gov" Index="0">
    <IPAddress>10.1.37.1</IPAddress>
  </RefNode>
  <RefNode Type="ROUTER" DnsName="router13.llnl.gov" Index="1">
    <IPAddress>10.1.37.2</IPAddress>
  </RefNode>
</Subnet>
<Subnet Cidr="10.1.38.0/24" Type="P2P" Name="p2p_38"
NodeContainer="p2p_38_nodes" DataRate="100Mbps" Delay="10ms">

```

```

    <Description>p2p_38_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router12.llnl.gov" Index="0">
      <IPAddress>10.1.38.1</IPAddress>
    </RefNode>
    <RefNode Type="ROUTER" DnsName="router5.llnl.gov" Index="1">
      <IPAddress>10.1.38.2</IPAddress>
    </RefNode>
  </Subnet>
  <Subnet Cidr="10.1.39.0/24" Type="P2P" Name="p2p_39"
NodeContainer="p2p_39_nodes" DataRate="100Mbps" Delay="8ms">
    <Description>p2p_39_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router13.llnl.gov" Index="0">
      <IPAddress>10.1.39.1</IPAddress>
    </RefNode>
    <RefNode Type="ROUTER" DnsName="router6.llnl.gov" Index="1">
      <IPAddress>10.1.39.2</IPAddress>
    </RefNode>
  </Subnet>
  <Subnet Cidr="10.1.40.0/24" Type="P2P" Name="p2p_40"
NodeContainer="p2p_40_nodes" DataRate="100Mbps" Delay="8ms">
    <Description>p2p_40_Subnet</Description>
    <RefNode Type="ROUTER" DnsName="router14.llnl.gov" Index="0">
      <IPAddress>10.1.40.1</IPAddress>
    </RefNode>
    <RefNode Type="ROUTER" DnsName="router6.llnl.gov" Index="1">
      <IPAddress>10.1.40.2</IPAddress>
    </RefNode>
  </Subnet>
  <Application xsi:type="PacketSinkAppType" Name="PacketSink"
Protocol="ns3::TcpSocketFactory" LocalAddress="0.0.0.0" LocalPort="80"
Start="0.0" Stop="1000"/>
  <Application xsi:type="OnOffAppType" Name="Client_0"
Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
RemoteAddress="10.1.31.2" Port="80" Start="22.8263" Stop="1000"/>
  <Application xsi:type="OnOffAppType" Name="Server_0"
Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
RemoteAddress="10.1.31.1" Port="80" Start="22.8263" Stop="1000"/>
  <Application xsi:type="OnOffAppType" Name="Client_1"
Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
RemoteAddress="10.1.35.2" Port="80" Start="29.3714" Stop="1000"/>
  <Application xsi:type="OnOffAppType" Name="Server_1"
Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
RemoteAddress="10.1.35.1" Port="80" Start="29.3714" Stop="1000"/>
  <Application xsi:type="OnOffAppType" Name="Client_2"
Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
RemoteAddress="10.1.13.2" Port="80" Start="63.0976" Stop="1000"/>
  <Application xsi:type="OnOffAppType" Name="Server_2"
Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
RemoteAddress="10.1.13.1" Port="80" Start="63.0976" Stop="1000"/>
  <Application xsi:type="OnOffAppType" Name="Client_3"
Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
RemoteAddress="10.1.4.2" Port="80" Start="9.21049" Stop="1000"/>
  <Application xsi:type="OnOffAppType" Name="Server_3"
Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
RemoteAddress="10.1.4.1" Port="80" Start="9.21049" Stop="1000"/>
  <Application xsi:type="OnOffAppType" Name="Client_4"
Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
RemoteAddress="10.1.6.2" Port="80" Start="43.3701" Stop="1000"/>
  <Application xsi:type="OnOffAppType" Name="Server_4"
Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
RemoteAddress="10.1.6.1" Port="80" Start="43.3701" Stop="1000"/>

```

```

    <Application xsi:type="OnOffAppType" Name="Client_5"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.12.2" Port="80" Start="43.0863" Stop="1000"/>
    <Application xsi:type="OnOffAppType" Name="Server_5"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.12.1" Port="80" Start="43.0863" Stop="1000"/>
    <Application xsi:type="OnOffAppType" Name="Client_6"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.11.2" Port="80" Start="15.4082" Stop="1000"/>
    <Application xsi:type="OnOffAppType" Name="Server_6"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.11.1" Port="80" Start="15.4082" Stop="1000"/>
    <Application xsi:type="OnOffAppType" Name="Client_7"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.14.2" Port="80" Start="7.70865" Stop="1000"/>
    <Application xsi:type="OnOffAppType" Name="Server_7"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.14.1" Port="80" Start="7.70865" Stop="1000"/>
    <Application xsi:type="OnOffAppType" Name="Client_8"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.37.2" Port="80" Start="88.9866" Stop="1000"/>
    <Application xsi:type="OnOffAppType" Name="Server_8"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.37.1" Port="80" Start="88.9866" Stop="1000"/>
    <Application xsi:type="OnOffAppType" Name="Client_9"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.28.2" Port="80" Start="89.3389" Stop="1000"/>
    <Application xsi:type="OnOffAppType" Name="Server_9"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.28.1" Port="80" Start="89.3389" Stop="1000"/>
    <Application xsi:type="OnOffAppType" Name="Client_10"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.7.2" Port="80" Start="46.4268" Stop="1000"/>
    <Application xsi:type="OnOffAppType" Name="Server_10"
    Protocol="ns3::TcpSocketFactory" DataRate="5000bps" PacketSize="500"
    RemoteAddress="10.1.7.1" Port="80" Start="46.4268" Stop="1000"/>
    <ApplicationSet Name="WebBrowsingSet0_0">
      <Application Name="PacketSink"/>
      <Application Name="Client_0"/>
    </ApplicationSet>
    <ApplicationSet Name="WebBrowsingSet0_1">
      <Application Name="PacketSink"/>
      <Application Name="Server_0"/>
    </ApplicationSet>
    <ApplicationSet Name="WebBrowsingSet1_0">
      <Application Name="PacketSink"/>
      <Application Name="Client_1"/>
    </ApplicationSet>
    <ApplicationSet Name="WebBrowsingSet1_1">
      <Application Name="PacketSink"/>
      <Application Name="Server_1"/>
    </ApplicationSet>
    <ApplicationSet Name="WebBrowsingSet2_0">
      <Application Name="PacketSink"/>
      <Application Name="Client_2"/>
    </ApplicationSet>
    <ApplicationSet Name="WebBrowsingSet2_1">
      <Application Name="PacketSink"/>
      <Application Name="Server_2"/>
    </ApplicationSet>
    <ApplicationSet Name="WebBrowsingSet3_0">
      <Application Name="PacketSink"/>
      <Application Name="Client_3"/>
    </ApplicationSet>

```

```

</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet3_1">
  <Application Name="PacketSink"/>
  <Application Name="Server_3"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet4_0">
  <Application Name="PacketSink"/>
  <Application Name="Client_4"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet4_1">
  <Application Name="PacketSink"/>
  <Application Name="Server_4"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet5_0">
  <Application Name="PacketSink"/>
  <Application Name="Client_5"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet5_1">
  <Application Name="PacketSink"/>
  <Application Name="Server_5"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet6_0">
  <Application Name="PacketSink"/>
  <Application Name="Client_6"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet6_1">
  <Application Name="PacketSink"/>
  <Application Name="Server_6"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet7_0">
  <Application Name="PacketSink"/>
  <Application Name="Client_7"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet7_1">
  <Application Name="PacketSink"/>
  <Application Name="Server_7"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet8_0">
  <Application Name="PacketSink"/>
  <Application Name="Client_8"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet8_1">
  <Application Name="PacketSink"/>
  <Application Name="Server_8"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet9_0">
  <Application Name="PacketSink"/>
  <Application Name="Client_9"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet9_1">
  <Application Name="PacketSink"/>
  <Application Name="Server_9"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet10_0">
  <Application Name="PacketSink"/>
  <Application Name="Client_10"/>
</ApplicationSet>
<ApplicationSet Name="WebBrowsingSet10_1">
  <Application Name="PacketSink"/>
  <Application Name="Server_10"/>
</ApplicationSet>
</NetSim>

```

## Appendix B. AddSystemId Python script

```
#!/usr/bin/env python
#
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#
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#

import sys, os, subprocess
from optparse import OptionParser

def main():
    # parse command line options
    parser = OptionParser()
    parser.add_option("-x", "--xndl", dest="xndlFile", help="xndl input file
[REQUIRED]", metavar="FILE")
    parser.add_option("-t", "--xslt", dest="xsltFile", help="xslt transform
file [REQUIRED]", metavar="FILE")
    parser.add_option("-m", "--metis", dest="metisFile", help="metis file
[REQUIRED]", metavar="FILE")

    (options, args) = parser.parse_args()

    # if have all three files on command line
    if checkFile(options.xndlFile) and checkFile(options.xsltFile) and
checkFile(options.metisFile):
        addSystemIds(options.xndlFile, options.xsltFile,
options.metisFile)

    # otherwise print help message and exit
    else:
        parser.print_help()
        return 2

    return 0

#
# ensure file exist
#
def checkFile(fname):
    if os.path.isfile(fname):
        return True

    print "Can't find file: " + fname
    return False

#
```

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# add SystemId attribute to xndl file
#
def addSystemIds(xndlFile, xsltFile, metisFile):

    # xmlize the metis file and save in current directory
    metisRankFname = xmlizeMetis(metisFile)

    # run xmlproc to create final xml with SystemId attribute
    subprocess.call(["xsltproc", "--stringparam", "metisrankfile",
metisRankFname, xsltFile, xndlFile])

    return

#
# add xml tags to each line of metis file
#
def xmlizeMetis(metisFile):
    # get output file name (same name as metis file)
    # and open output file
    outFname = os.path.basename(metisFile) + ".xml"
    outFile = open(outFname, 'w')

    # add first line comment and start <ranks> element
    outFile.write("<!-- METIS output rank assignments -->\n")
    outFile.write("<ranks>\n")

    # add xml tags <rank>...</rank> to each line
    for line in open(metisFile, 'r'):
        outFile.write("<rank>" + line.strip() + "</rank>")

    # close 'ranks' element
    outFile.write("</ranks>\n")

    return outFname

if __name__ == "__main__":
    sys.exit(main())

```